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MACROELEMENT CHANGES OF *TRACHYSTEMON ORIENTALIS* (L.) G. D O N (BORAGINACEAE) UNDER DIFFERENT FOREST COMMUNITIES

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Abstract

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In this study, the effects of different forest communities on the macroelement (N, P and K) concentrations in above and below ground organs of *Trachystemon orientalis* (L.) G. D o n individuals according to different phenophases were investigated**.**

In both forest communities, macroelement concentrations of aboveground parts were higher than that of belowground parts during vegetative growth period while belowground parts were rich in macroelement concentrations as compared to aboveground parts during generative growth period. In addition to these, N, P and K concentrations of *T. orientalis* individuals under *Fagus orientalis* L i p s k y (Fagaceae) forest were higher than that of the individuals under *Carpinus orientalis* M i l l e r subsp. *orientalis* (Corylaceae) forest. The soils under these forests were rich in nutrients during vegetative growth period as compared to generative growth period. Some *T. orientalis* individuals were remained at vegetative phase although some of them were completed their growth cycles.

Key words: Trachystemon orientalis, macroelements, phenophases

Introduction

Deciduous forest spring ephemerals heavily rely on the high light period in early spring, prior to canopy closure, for carbon fixation and carbohydrate accumulation (Routhier, Lapointe, 2002). Because in deciduous understory plants, temperature seems not to be so closely associated to flowering time as has often been claimed, while canopy closure clearly defines the later limit of the flowering season (Gonzáles et al., 1996). According to Akpo (1997) phenological growth of meadow vegetation and tree canopy was synchronous.

Primack (1985) was reported that; in deciduous forest understory vegetation show that the availability of sufficient light to maintain active rates of photosyntesis may restrict the flowering and growing season. So that, within a forest, variation in tree leaf phenology across species affected the number of flowers and fruits produced by the understory shrub *Staphylea bumalda* (Maeno, Hiura, 2000). Because understory PPFD (photosyntetic photon flux density) condition which in a deciduous broad-leaves forest in relation to the leaf phenology of overstory trees and its quite different as seasonality (Kato, Komiyama, 2002). Tree leaf phenology varies among species, but also along latitudinal gradients (Lechowicz, 1984). Uemura (1994) shows that, seasonal changes in light conditions will vary between forests owing to variations in the heterogenity of trees and their foliation phenology.

The comparison of the phenological cycles of the same species in different woods reveals how important it is to know how the climatic modifications produced by wooded vegetation affect large numbers of plant species (Gonzáles et al., 1996). Ratcke, Lacey (1985) reported that, the flowering phenology of different populations of the same species is determined by environmental parameters and allows for genetic exchange and increases the visits of polinators. A knowledge of the characteristic phenelogical variations of the understory plants in these forests is important for the understanding of the dynamics of the two communities, while also indicating these species response to climatic and edaphic conditions in the area (Gonzáles et al., 1996).

Trachystemon orientalis is a Euro-Siberian geophytic plant that distributed around Eastern Bulgaria, Western Caucasica and Northern Turkey under forest canopies (Davis, 1978). It has been used as food with its peduncles, leaves and rhizome (Yildirimli, 1994) and a medicinal plant (Baytop, 1984). We were aimed the effects of different forest communities on macroelement (N, P and K) concentrations in above and belowground parts of *T. orientalis* with respect to phenophases. Additionally, we also investigated the changes in soil macroelement concentrations releated to phenophases.

Materials and methods

Two different localities were selected from two different forest canopies which the species was naturally occured. The first locality was 500 m far from the sea (15 m a. s. l.) and located under a *Carpinus orientalis* subsp. *orientalis* M i l l e r (Corylaceae) forest on the campus area of Ondokuz Mayis University (It was called as "lower locality" henceforth). The second locality was 15 km far from the sea (1250 m a. s. l.) and located under a *Fagus orientalis* L i p s k y (Fagaceae) forest near the Kocadag TV station (Samsun). (It was called as "upper locality" henceforth). Three 200x20 m plots were selected from lower, slope and upper elevations in each of two localities.

Plant and soil samples were collected during initial phase, flowering phase, fruiting phase and senescence and the date in which the number of induvidually reached to for chemical analysis (Table 1). Soil samples were taken at a depth of 20 cm from different places of each plot. They were air-dried and sieved to a 2 mm mesh.

Texture was determined by the method of Bouyoucus (1951) and pH was measured with "Beckman pH meter" (Bayrakli, 1987). $CaCO_3$ (%) and organic matter (%) were determined according to Hizalan, Unal (1996) and Bayrakli (1987) respectively. N (%) was determined by using a Kjeltec apparatus with Kjeldahl method (Bayrakli (1987). Available phosphorus (P_2O_5) and potassium (%) were determined by Bayrakli (1987) and

flame photometer after extraction with 25% cold HCl, respectively. The results of soil analysis were explained according to Chapmann, Pratt (1973) and Bayrakli (1987).

Plant samples were taken according to phenological phases (phenophases) and rhisome, leaf, flower and fruit samples were obtained. They were dried at 70 °C for 24 hours. After that they were powdered in the hammer mill and N (%) concentrations were determined like soil samples P (%) concentrations were determined according to Kaçar (1992).

Statistical analysis were performed by using Balanced MANOVA (Anonymous, 1999). Tukey's Honestly Significance (HSD) test was also used to compare group means following MANOVA.

Table 1. Harvest date of plant and soil samples

Localities	Phenophases	Date of harvest
Lower	Initial phase	First week of March
	Flowering	Second week of April
	Fruiting	Third week of May
	Senescence	Fourth week of September
Upper	Initial phase	Second week of March
	Flowering	Third week of April
	Fruiting	Third week of May
	Senescence	First week of October

Climatic diagrams were drawed according to Walter method (Cireli et al., 1983) (Figs. 1, 2). Temperates and precipitation values were calculated by enterpolation from meteorological station of Samsun (Erinç, 1965; Dogan, 1977).

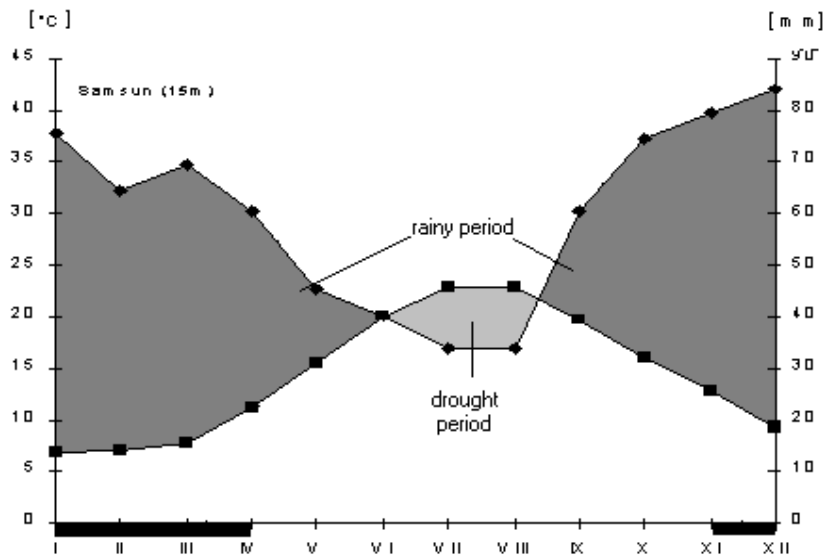

Fig. 1. Climatic diagram of lower locality.

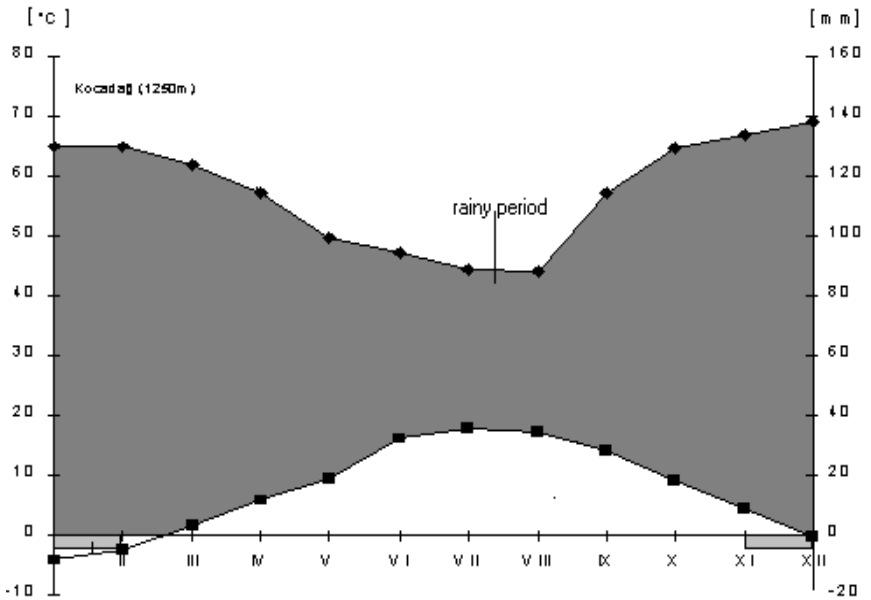

Fig. 2. Climatic diagram of upper locality.

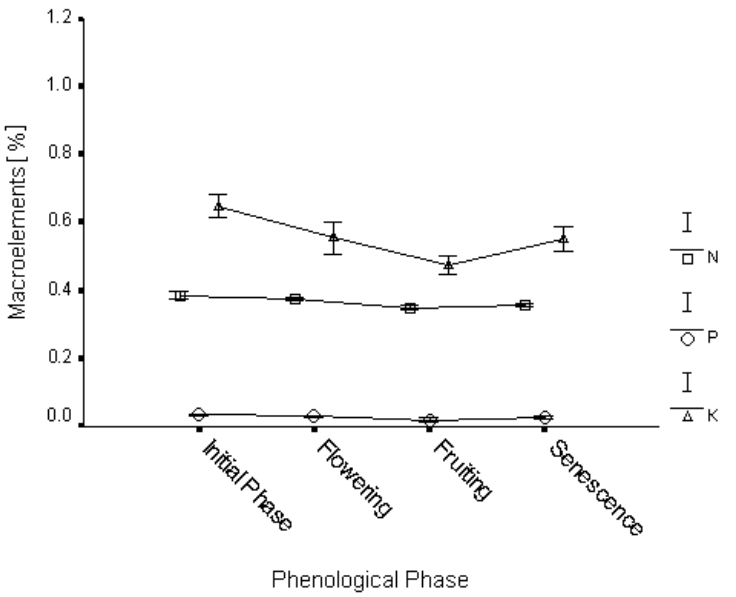

Fig. 3. The change of N, P, K concentrations in soils on lower localities according to phenological phases (Standard errors were indicated).

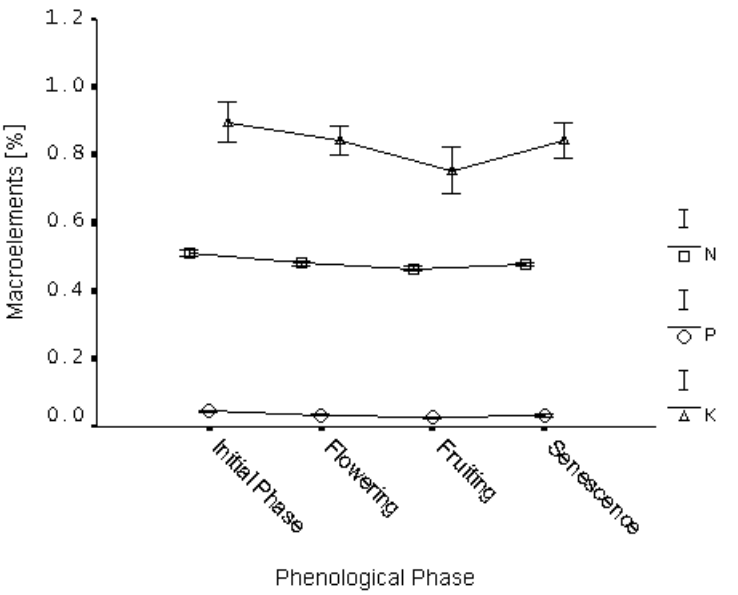

Fig. 4. The change of N, P, K concentrations in soils on upper localities according to phenological phases (Standard errors were indicated).

Results

Annual temperature in lower and upper localities was 15.3 and 8.3 °C, respectively. Annual precipitation was 639.1 and 1288.6 mm in lower and upper localities, respectively. A drought period was observed only lower locality (Fig. 1, 2). The number of snowy days in lower and upper localities were 7 and 30 days, respectively.

Trachystemon orientalis occurs on sandy-clayey-loamy, slightly and medium acidic, non-calcareous and non-saline soils. According to soil macroelements this species prefers the soil rich in nitrogen and medium rich in potassium. However, it occurs on on the soils that low in phosphorus (Chapmann, Pratt, 1973; Bayrakli, 1987).

Soil macroelement concentrations (N, P and K) were significantly changed in terms of phenophases and localities. N, P and K (%) concentrations were higher in upper locality than that of lower locality in all phenophases. N, P, K concentrations were not significantly changed between phenophases and localities (Table 2). Soil N, P and K (%) concentrations were decreased during flowering and fruiting phases according to initial phase in both localities (Fig. 3, 4).

N and P (%) concentrations between plant parts were different significantly, while K (%) concentrations were not differed significantly. N, P and K (%) concentrations were significantly changed according to phenophases. However, only N (%) concentrations were sig-

T a b l e 2. The BALANCED MANOVA test of N, P, K [%] concentrations in soil according to locality and phenophases

Source	Variable	dF	MS	F	P
Phenological phases	N	3	$1.84.\ 10^{-3}$	44.06	0.000*
	P	3	$2.83.\ 10^{-4}$	33.50	0.000*
	K	3	$2.45.\ 10^{-2}$	14.28	0.000*
Locality	N	1	$8{,}22.\ 10^{-2}$	1964.20	0.000*
	P	1	$3.01.\ 10^{-4}$	35.59	0.000*
	K	1	0.45	265.28	0.000*
Phenological phases* locality	N	3	$8.01.\ 10^{-5}$	1.91	N. S.
	P	3	$7.81.\ 10^{6}$	0.92	N. S.
	K	3	$5.93.\ 10^{-4}$	0.34	N. S.
Error	N	16	$4.18.\ 10^{-5}$	–	–
	P	16	$4.18.\ 10^{-5}$	–	–
	K	16	$1.72.\ 10^{-3}$	–	–

* $P < 0.01$, N. S. (not significant) > 0.01

nificantly changed according to localities**.** The interaction between localities and plant macroelement concentrations was statistically significant.

Statistically significant differences were found in terms of plant N (%) concentrations with respect to all of the studied parameters. There were also significant differences in terms of plant P and K (%) concentrations according to phenophases. Similarly the interaction between locality and plant parts were also significant in all nutrients. The interaction amongst plant parts, locality and phenophases were statistically significant in terms of K (%) concentrations. Similarly there were significant differences between above and belowground plant parts in terms of P (%) concentration. The other interactions were not mostly statistically significant.

N and P (%) concentrations between plant parts were differed significantly, while K (%) concentrations were not differed significantly. N, P and K (%) concentrations were significantly changed according to phenophases. However, only N (%) concentrations were significantly changed according to localities. The interaction between localities and plant macroelement concentrations was statistically significant.

Plant parts were only significantly different from each other in terms of N (%) concentration according to phenophases. There were significant differences between phenophases in both localities in terms of N and K (%) concentrations. Similarly different plant parts were significantly different from each other in terms of N and K (%) concentrations in both localities (Table 3 and 4).

According to the results of Tukey's HSD test flowers and leaves had the highest N and P (%) concentrations. Soil N, P and K (%) concentrations during initial phase were different from other phases. Rhizome had different macroelement concentrations as compared to fruit, leaf and flower in both localities (Table 5–8).

T a b l e 3. Mean values and standard errors for N, P and K [%] concentrations in above – belowground parts of *Trachystemon orientalis* on the lower and upper localities

			Plant parts			
		Phenophases	Rhizome	Fruit	Leaf	Flower
LOWER LOCALITY	N	Initial phase	$0.13 \pm 1.73. 10^{-3}$	–	–	–
		Flowering	$0.14 \pm 1.15. 10^{-3}$	–	$0.24 \pm 1.00. 10^{-3}$	$0.25 \pm 6.66. 10^{-4}$
		Fruiting	$0.16 \pm 1.45. 10^{-3}$	$0.17 \pm 1.39. 10^{-2}$	$0.21 \pm 6.06. 10^{-3}$	–
		Senescence	$0.15 \pm 1.45. 10^{-3}$	–	$0.22 \pm 2.33. 10^{-3}$	–
	P	Initial phase	$2.33. 10^{-2} \pm 8.81. 10^{-4}$	–	–	–
		Flowering	$2.36. 10^{-2} \pm 4.70. 10^{-3}$	–	$5.36. 10^{-2} \pm 2.02. 10^{-3}$	$6.20. 10^{-2} \pm 1.52. 10^{-3}$
		Fruiting	$3.26. 10^{-2} \pm 2.72. 10^{-3}$	$5.66. 10^{-2} \pm 2.33. 10^{-3}$	$5.20. 10^{-2} \pm 5.68. 10^{-3}$	–
		Senescence	$2.56. 10^{-2} \pm 3.66. 10^{-3}$	–	$5.03. 10^{-2} \pm 3.33. 10^{-4}$	–
	K	Initial phase	$0.11 \pm 2.96. 10^{-3}$	–	–	–
		Flowering	$0.13 \pm 1.15. 10^{-3}$	–	$0.18 \pm 2.84. 10^{-3}$	$0.20 \pm 2.30. 10^{-3}$
		Fruiting	$0.15 \pm 1.45. 10^{-3}$	$0.19 \pm 1.45. 10^{-3}$	$0.17 \pm 4.70. 10^{-3}$	–
		Senescence	$0.14 \pm 2.40. 10^{-3}$	–	$0.19 \pm 1.45. 10^{-3}$	–
UPPER LOCALITY	N	Initial phase	$0.14 \pm 2.33. 10^{-3}$	–	–	–
		Flowering	$0.15 \pm 2.08. 10^{-3}$	–	$0.31 \pm 1.73. 10^{-3}$	$0.27 \pm 7.02. 10^{-3}$
		Fruiting	$0.16 \pm 2.33. 10^{-3}$	$0.20 \pm 4.37. 10^{-3}$	$0.25 \pm 5.23. 10^{-3}$	–
		Senescence	$0.15 \pm 1.15. 10^{-3}$	–	$0.22 \pm 6.66. 10^{-4}$	–
	P	Initial phase	$1.73. 10^{-2} \pm 1.45. 10^{-3}$	–	–	–
		Flowering	$2.30. 10^{-2} \pm 2.51. 10^{-3}$	–	$5.90. 10^{-2} \pm 6.65. 10^{-3}$	$5.26. 10^{-2} \pm 2.18. 10^{-3}$
		Fruiting	$3.40. 10^{-2} \pm 2.08. 10^{-3}$	$4.36. 10^{-2} \pm 1.85. 10^{-3}$	$5.83. 10^{-2} \pm 8.81. 10^{-4}$	–
		Senescence	$2.63. 10^{-2} \pm 8.81. 10^{-4}$	–	$5.20. 10^{-2} \pm 1.15. 10^{-3}$	–
	K	Initial phase	$0.10 \pm 2.33. 10^{-3}$	–	–	–
		Flowering	0.36 ± 0.10	–	$0.15 \pm 2.02. 10^{-3}$	$0.17 \pm 1.15. 10^{-3}$
		Fruiting	$0.17 \pm 4.33. 10^{-3}$	$0.16 \pm 1.76. 10^{-3}$	$0.15 \pm 2.64. 10^{-3}$	–
		Senescence	$0.15 \pm 2.88. 10^{-3}$	–	$0.14 \pm 2.40. 10^{-3}$	–

T a b l e 4. The BALANCED MANOVA test of N, P, K [%] concentrations in different plant parts according to locality and phenophases

Source	Variable	dF	MS	F	P
Phenological phases	N	3	$1.33.\ 10^{-3}$	22.02	0.000*
	P	3	$1.49.\ 10^{-4}$	5.72	0.003*
	K	3	$1.62.\ 10^{-2}$	8.56	0.000*
Locality	N	1	$5.36.\ 10^{-3}$	88.56	0.000*
	P	1	$1.64.\ 10^{-4}$	6.32	N.S.
	K	1	$1.84.\ 10^{-3}$	0.97	N.S.
Plant parts	N	3	$2.76.\ 10^{-2}$	457.24	0.000*
	P	3	$2.58.\ 10^{-3}$	99.33	0.000*
	K	3	$2.45.\ 10^{-3}$	$2.45.\ 10^{-3}$	N.S.
Locality * phenological phases	N	3	$8.25.\ 10^{-4}$	13.64	0.000*
	P	3	$1.91.\ 10^{-5}$	0.73	N.S.
	K	3	$1.17.\ 10^{-2}$	6.18	0.002*
Plant parts * phenological phases	N	2	$4.06.\ 10^{-3}$	67.11	0.000*
	P	2	$9.85.\ 10^{-5}$	3.78	N.S.
	K	2	$8.12.\ 10^{-3}$	4.28	N.S
Locality * plant parts	N	3	$8.14.\ 10^{-4}$	13.45	0.000*
	P	3	$1.51.\ 10^{-4}$	5.82	0.002*
	K	3	$1.60.\ 10^{-2}$	8.46	0.000*
Plant parts * locality * phenological phases	N	2	$1.04.\ 10^{-3}$	17.18	0.000*
	P	2	$5.25.\ 10^{-6}$	0.20	N.S.
	K	2	$9.94.\ 10^{-3}$	5.24	0.010*
Error	N	36	$6.05.\ 10^{-5}$	–	–
	P	36	$2.60.\ 10^{-5}$	–	–
	K	36	$1.89.\ 10^{-3}$	–	–

T a b l e 5. Tukey's (HSD) results of N, P, K [%] concentrations in different plant parts on lower locality. It is not significantly different at the 0.05 level using Tukey's HSD test

	Rhizome	Fruit	Leaf	Flower
N	0.14 c	0.17 b	0.22 a	0.25 a
P	$2.63\ .\ 10^{-2}$ b	$5.66\ .\ 10^{-2}$ a	$5.20\ .\ 10^{-2}$ a	$6.20\ .\ 10^{-2}$ a
K	0.13 b	0.19 a	0.18 a	0.20 a

Discussion

Soils N, P and K (%) concentrations were significantly different from upper and lower localities. This probably may be due to differences between both localities in terms of altitude, temperature, precipitation and other abiotic factors. Chen et al. (1997) shown that topografic variables are more significant than the vegetation types in explaining the soil data. Gonzáles et al. (1996) were observed significant differences between oak (*Quercus pyrenaica*) and beech (*Fagus sylvatica*) forests with respect to air temperature, relative humidity, soil moisture, P.A.R (photosynthetically active radiation) and number of daylight hours.

T a b l e 6. Tukey's (HSD) results of N, P, K [%] concentrations in different plant parts on upper locality. It is not significantly different at the 0.05 level using Tukey' s HSD test

	Rhizome	Fruit	Leaf	Flower
N	0.15 c	0.20 b	0.26 a	0.27 a
P	$2.51 . 10^{-2}$ c	$4.36 . 10^{-2}$ b	$5.64 . 10^{-2}$ a	$5.26 . 10^{-2}$ ab
K	0.19 a	0.16 a	0.15 a	0.17 a

T a b l e 7. Tukey's (HSD) results of N, P, K [%] concentrations in soils on lower locality. It is not significantly different at the 0.05 level using Tukey' s HSD test

	Initial phase	Flowering	Fruiting	Senescence
N	0.38 a	0.37 ab	0.34 c	0.35 bc
P	$3.56 . 10^{-2}$ a	$3.00 . 10^{-2}$ ab	$2.00 . 10^{-2}$ c	$2.63 . 10^{-2}$ bc
K	0.64 a	0.55 b	0.47 b	0.55 b

T a b l e 8. Tukey's (HSD) results of N, P, K [%] concentrations in soils on upper locality. It is not significantly different at the 0.05 level using Tukey' s HSD test

	Initial phase	Flowering	Fruiting	Senescence
N	0.51 a	0.48 b	0.46 b	0.47 b
P	$4.53 . 10^{-2}$ a	$3.43 . 10^{-2}$ b	$2.80 . 10^{-2}$ b	$3.26 . 10^{-2}$ b
K	0.89 a	0.84 ab	0.75 b	0.84 ab

Significant differences with respect to phenophases in soil N, P and K (%) concentrations may be due to the using of macroelements in rhizomes during vegetative growth period, while the using of macroelements in soil during generative growth phase (Pirdal, 1989; Kilinç, Yüksel, 1995; Kutbay, Kilinç, 1995). Canadell, Vilá (1992) and Kutbay, Kilinç (2002) were found negative correlations between plant and soil nutrient concentrations.

Significant differences in terms of above and belowground N concentrations according to sampling localities were explaned on the basis of abiotic (altitude, temperature, precipitation, etc.). Routhier, Lapointe (2002) reported C stocks of *Trillium erectum* (Liliaceae) were changed according to localities and gradient from south to north and such differences were depending on the differences in abiotic factors. Chang et al. (1998) were also showed day length was effected on flowering and protein mechanism of *Polianthes tuberosa* L. In the present study, both localities were different from each other in terms of abiotic factors (altitude, temperature, precipitation, soil properties, etc.) like other studies.

The changes of N, P and K (%) concentrations in above and below ground parts of *Trachystemon orientalis* according to phenophases were significant. In both localities aboveground macroelement concentrations were higher during vegetative growth phase,

whilst macroelement concentrations were higher in belowground parts (rhizome) as compared to aboveground parts during generative growth phase.

Leopold (1980) is distinguished various senescence types in different plants. In some plants the aboveground plant organs senesce completely and new shoots appear at the beginning of the next season. Such senescence called as "top senescence". The reserves in the vegetative storage organs allow a rapid growth during initial phase (Berchtold et al., 1993). In the present study, macroelement concentrations of rhizome were significantly different from fruit, leaf and flower. Macroelements in different organs of *Trachystemon orientalis* have been redistributed according to different phenophases and this redistribution is highly important for the economical using of nutrients (Feller, Fischer, 1994). At the beginning of the growing season, the amount of nitrogen was probably high as a result of nitrogen stored in roots (Kull et al., 1998).

The growth of aboveground parts of *Trachystemon orientalis* were initated at the second half February and the growth was incrased during early spring. Herb species in semi-arid savannas need short and damp period (60 days) to finish their life cycle (Akpo, 1997), although spring ephemerals under deciduous forests need high irradiances to carbon fixation and carbonhydrate accumulation (Routhier, Lapointe, 2002). As a result of this, plant species consumed previous years belowground stocks (Lapointe, 1998; Routhier, Lapointe, 2002; Kutbay, Kilinç, 2002)

Anderson, Eickmeier (2000) stated according to vernal dam hypothesis forest herbs temporarily sequester nutrients in deciduous forests prior to canopy closure and return them to the belowground tissues following senescence of aboveground tissues.

Macroelement concentration of aboveground plant parts were incrased meristematic tissues in fast growing aboveground parts need high macroelement concentrations (Werger, Hirose, 1991; Brohi et al., 1994; Kadioglu, 1998). Such results were reported by other researchers (Pirdal, 1989; Méndez, 1999; Kutbay, Kilinç, 2002).

Leaf senescence has an important role in the plant's nitrogen economy (Feller, Fischer, 1994). High macroelement concentrations in belowground parts (rhizome) during generative period due to aboveground senescence. At first half of May some individuals finished flowering period and senescence aboveground parts may be occurred due to the low light conditions as a result of the full-leaf expension of canopy trees (Goryshina, 1972; Lapointe, 1998). The interaction between environmental and genetic factors was significant for the activation of "protein transporters" which is responsible for protein transport from senescing leaves to belowground parts (Ortiz-Lopez et al., 2000; Thomas et al., 2002). Due to senescence phenomena macroelements transferred to belowground parts (Leopold, 1980) and *Trachystemon orientalis* completed rizome storages during early spring (Lapointe, 1998), and during the first half of the following spring the new growth period begins (Routhier, Lapointe, 2002). Senescence is an important process in the adaptation of higher plants to environmental conditions. Interaction between above- and belowground parts which on initial and generative phases is important eco-physiological properties of geophytes (Feller, Fischer, 1994). Senescence is allowed to the optimum usage of macroelements for a plant (Jayasekera, 1983). In addition to this, plant individuals adapted to catastrophic

factors such as fire, severe defoliation or freezing and adaptation to high irradiance during early spring by the help of senescence (Lapointe, 1998). The reserves in vegetative storages organs allow a rapid growth during initial phase (Steinmann et al., 1984; Berchtold et al., 1993). Such results were also found by Gökçeoglu (1975), Pirdal (1989), Kutbay (1999), Méndez (1999) and Kutbay, Kilinç (2002) in some Monocotyledonous geophytes.

Conclusions

Soil macroelement concentrations (N, P and K) were significantly changed in terms of phenophases and localities. Chen et al. (1997) shown that topografic variables are more significant than the vegetation types in explaining the soil data. N, P and K (%) concentrations were higher in upper locality than that of lower locality in all phenophases. N, P and K concentrations were not significantly changed between phenophases and localities. Soil N, P and K (%) concentrations were decreased during flowering and fruiting phases comprising to initial phase in both localities N and P (%) concentrations between plant parts were different significantly, while K (%) concentrations were not differed significantly. N, P and K (%) concentrations were significantly changed according to phenophases. However, only N (%) concentrations were significantly changed according to localities.

There were also significant differences in terms of plant P and K (%) concentrations according to phenophases. Similarly the interaction between locality and plant parts were also significant in all nutrients. N and P (%) concentrations between plant parts were different significantly, while K (%) concentrations were not differed significantly. N, P and K (%) concentrations were significantly changed according to phenophases. However, only N (%) concentrations were significantly changed according to localities.

Plant parts were only significantly different from each other in terms of N (%) concentration according to phenophases. There were significant differences between phenophases in both localities in terms of N and K (%) concentrations. Similarly different plant parts were significantly different from each other in terms of N and K (%) concentrations in both localities.

Soil N, P and K (%) concentrations during initial phase were different from other phases. Rhizome had different macroelement concentrations as compared to fruit, leaf and flower in both localities.

Translated by the authors

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Korkmaz H., Yildiz M., Kutbay H.G., Yalçin E., Bilgin A.: **Zmeny makroelementov u** *Trachystemon orientalis* (L.) G. D o n (Boraginaceae) **pod rôznymi lesnými spoločenstvami.**

V tejto práci sa zaoberáme výskumom vplyvov rôznych lesných spoločenstiev na koncentrácie makroelementov (N, P a K) v nadzemných i podzemných orgánoch jednotlivcov *Trachystemon orientalis* (L.) G. D o n podľa rôznych fenofáz.

V oboch lesných spoločenstvách koncentrácie makroelementov nadzemných častí boli počas vegetačného rastu vyššie ako v podzemných častiach, kým podzemné časti boli počas generatívneho vegetačného obdobia bohaté v koncentráciách makroelementov v porovnaní s nadzemnými časťami. Koncentrácie N, P, a K u jednotlivcov *T. orientalis* pod lesmi s *Fagus orientalis* L i p s k y (Fagaceae) boli vyššie ako u jednotlivcov pod lesmi s *Carpinus orientalis* M i l l e r subsp. *orientalis* (Corylaceae). Pôdy pod týmito lesmi boli bohatšie na živiny počas obdobia vegetačného rastu v porovnaní s generatívnym vegetačným obdobím. Niektorí jednotlivci *Trachystemon orientalis* zostali vo vegetačnej fáze, hoci mnohé z nich svoj rastový cyklus dokončili.